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Actors' roles and perceptions on the opportunities to increase nature conservation effectiveness:

A study of interaction between knowledge and policy process

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Abstract

Scientific knowledge shows compelling evidence of intensifying global environmental problems such as biodiversity loss and climate change. Unfortunately, this knowledge has not been directly translated into actions that would have reversed these worrying trends. The effectiveness of conservation, i.e. its ability to produce a desired result, is the outcome of interaction between knowledge and policy process. Efforts have recently been made to use existing scientific knowledge to combine current policy instruments and to develop new innovative approaches to conservation.

In this PhD thesis I empirically study the perspectives of various actors and their roles in topical Finnish conservation efforts: green infrastructure, voluntary forest conservation and conflicting peatland policy. I examine how different knowledge types and policy instruments contribute to conservation effectiveness. The study utilizes an expert survey, focus groups, combining multiple methods using the case study approach, and integrating social and ecological data.

The results illustrate how actors may interpret differently complex concepts, such as ecosystem services and ecological connectivity; the use of these concepts may even be politically coloured. Ambiguity concerning the definition of green infrastructure may create obstacles for practical implementation. In the peatland conservation policy case, where actors' interests differed, implemented policy instruments did not match existing knowledge. The role of other knowledge types along with ecological knowledge may be more important when designing voluntary rather than compulsory instruments, because participation to voluntary actions needs to be attractive. The collaboration of actors is an integral part of increasing conservation efforts in the voluntary conservation. Interaction and valuation of various knowledge types may have a complicating effect on conservation practices, but different knowledge types can be integrated for more effective results.

The study shows that policies should be designed in a way that allows the practical application of knowledge. The study elucidates what kind of challenges and opportunities for increasing effectiveness are faced in different phases of a policy process. I argue that the use of scientific evidence must be combined with the usage of other knowledge types and involvement of various actors. In addition, potential interest differences of actors should be considered when planning participation. In this way a combination of policy instruments can be developed, which simultaneously increases evidence uptake, acceptance and effectiveness leading to a more sustainable future.

Tiivistelmä

Vaikka tiede on osoittanut maailmanlaajuisten ympäristöongelmien, kuten monimuotoisuuskadon ja ilmastonmuutoksen pahenevan, tieto ei ole kuitenkaan johtanut riittävän vaikuttaviin tekoihin. Luonnonsuojelun tehokkuus, eli kyky tuottaa haluttu tulos, on tiedon ja politiikkaprosessien välisen vuorovaikutuksen tulos. Viime aikoina olemassa olevaa tietoa on pyritty hyödyntämään kehitettäessä erilaisten politiikkakeinojen yhdistelmiä sekä uusia luonnonsuojelun lähestymistapoja.

Väitöskirjassa tutkin eri toimijoiden käsityksiä ja heidän roolejaan ajankohtaisissa suomalaisissa luonnonsuojelun tapauksissa: vihreän infrastruktuurin politiikassa, vapaaehtoisessa metsiensuojelussa ja konfliktisoituneessa suopolitiikassa. Tarkastelen myös, miten eri tiedon lajit ja politiikkakeinot edesauttavat luonnonsuojelua. Tutkimuksessa hyödynnetään asiantuntijakyselyä, ryhmäkeskusteluja, sosiaalisen ja ekologisen aineiston yhdistämistä sekä useita menetelmiä yhdistävää tapaustutkimusta.

Väitöskirjan tulokset havainnollistavat, kuinka toimijat voivat tulkita monimutkaisia käsitteitä eri tavoilla, jopa poliittisesti värittyneesti. Tällaisia monitulkintaisia käsitteitä ovat esimerkiksi vihreä infrastruktuuri, ekologinen kytkeytyneisyys ja ekosysteemipalvelut. Vihreän infrastruktuurin monitulkintaisuus voi asettaa haasteita sen käytännön toimeenpanolle. Suopolitiikassa, jossa toimijoilla oli vahvoja intressiristiriitoja, toimeenpannut suojelukeinot olivat osin ristiriidassa ekologisen tiedon kanssa. Muunlaisen tiedon hyödyntäminen ekologisen tiedon lisäksi voi olla tärkeämpää vapaaehtoisten toimien suunnittelussa kuin sitovien lakisääteisten toimenpiteiden kohdalla, koska vapaaehtoisiin toimiin osallistumisen tulee olla houkuttelevaa. Myös eri toimijoiden yhteistyö on oleellinen osa vapaaehtoisen luonnonsuojelun edistämistä. Eri tiedon lajien (muun muassa luonnontieteellinen, yhteiskuntatieteellinen ja paikallinen tieto) vuorovaikutus ja arvottaminen voivat monimutkaistaa suojelun toimeenpanoa, mutta erilaisia tiedon lajeja voidaan yhdistää nykyistä tehokkaampien tulosten saamiseksi.

Tutkimus osoittaa, että ympäristöpolitiikka tulee suunnitella niin, että tiedon soveltaminen paikallisissa oloissa on mahdollista. Tutkimukseni nostaa näkyviin, millaisia erilaisia haasteita ja mahdollisuuksia lisätä luonnonsuojelun tehokkuutta on politiikkaprosessin eri vaiheissa. Luonnontieteellisen tiedon hyödyntäminen ei yksin riitä. Väitän, että luonnontieteiden lisäksi tulee hyödyntää muita tiedon lajeja ja toimijoiden osallistamista. Lisäksi eri toimijoiden mahdolliset eriävät intressit tulee ottaa huomioon jo osallistumisen tapoja suunniteltaessa. Näin voidaan kehittää politiikkakeinojen yhdistelmiä, jotka samalla lisäävät tieteellisen tiedon käyttöä sekä luonnonsuojelun hyväksyttävyyttä ja tehokkuutta johtaen nykyistä kestävämpään tulevaisuuteen.

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Peatland case has been the least straightforward of my research cases. In the beginning of my PhD, it looked like a good example of using latest ecological knowledge in policy, but changed to a much more complicated and politically coloured case. For a doctoral candidate, conducting research on a politically highly visible and conflicting case does not only feel rewarding but also a bit scary. Therefore, I would like to thank Eini Nieminen and Eerika Albrecht for providing feedback on my research, which was not done as a part of a big group. Of course thanks also to Ari for co-authoring and for some interesting discussions concerning relationship of legislation and nature.

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In addition to all the thanks, I want to make a statement. I think that society should put more effort into finding a more sustainable way of life. There should also be more thoughts of joy, rest and enthusiasm and less "efficiency" towards increased GDP. I think I should say this because I have managed to complete a PhD relatively efficiently and for most of the time to enjoy the journey. The future seems uncertain, for me as well as other people of my age (and with same interests), as the interest of government and many other decision-makers seem to be elsewhere than in nature, education, research, or building a truly sustainable future. You who are reading this, instead of ignorance to other people's problems and despite of some difficulties, do try to make others' work and life more enjoyable and aim at building the spirit for saving the world.

Anna Salomaa

Helsinki, November 2017

Contents

List of original publications

This thesis is based on the following publications.

I **Salomaa A.**, Paloniemi R., Kotiaho J.S., Kettunen M., Apostolopoulou E. & Cent J. 2017. Can green infrastructure help to conserve biodiversity? *Environment and Planning C: Politics and Space* 35(2): 265–288. https://doi.org/10.1177/0263774X16649363

II **Salomaa A.**, Paloniemi R., Hujala T., Rantala S., Arponen A. & Niemelä J. 2016. The use of knowledge in evidence-informed voluntary conservation of Finnish forests. *Forest Policy and Economics* 73: 90–98. http://dx.doi.org/10.1016/j.forpol.2016.09.004

III Paloniemi R., Hujala T., Rantala S., Harlio A., **Salomaa A.**, Primmer E., Pynnönen S. & Arponen A. 2017. Integrating social and ecological knowledge for targeting voluntary biodiversity conservation. *Conservation Letters* (published online) doi.wiley.com/10.1111/conl.12340

IV **Salomaa A.**, Paloniemi R. & Ekroos A. The case of conflicting Finnish peatland management - skewed representation of nature, participation and policy instruments (manuscript)

The publications are referred to in the text by their roman numerals.

Author contributions in the articles

Article	Idea for the article	Data collection	Data analysis	Manuscript preparation
I	AS (discussions with RP and JK).	AS prepared the Finnish survey with RP. EA, JC participated in planning the data collection.	AS responsible for analysis. JK and RP participated.	AS had leading role, RP, JK, MK, EA and JC participated.
II	AS (discussions with RP).	AS responsible for study design, participated in data collection as facilitator. RP, TH, SR, AA participated in data collection.	AS responsible for analysis. RP, TH participated in analysing, others supported conducting the analysis.	AS had leading role, RP, TH, SR, AA, JN participated.
III	RP, TH, AA (discussions with all authors).	AS responsible for study design of the workshop discussions (same as in II). RP, TH, EP and SP responsible for survey design. AH and AA responsible for spatial data.	AS participated in analysis and interpretation of results of the workshop discussions with RP, TH and SR. AH and AA had main responsibility for developing spatial prioritization on ecological values and TH, RP and SP had responsibility of analysing quantitative survey. All authors participated in integrating the results, but RP had main responsibility.	AS contributed in writing sections related to workshops, writing Introduction and Discussion. All authors participated and RP had the leading role.
IV	AS (discussions with RP and AE).	AS had main responsibility of selecting the materials, RP participated. AE participated especially by providing observations.	AS had main responsibility. RP and AE supported in conducting the analysis.	AS had leading role, RP and AE mainly commented.

AS = Anna Salomaa, RP= Riikka Paloniemi, JK= Janne Kotiaho, MK = Marianne Kettunen, EA = Evangelia Apostolopoulou, JC = Joanna Cent, TH = Teppo Hujala, SR = Salla Rantala, AA = Anni Arponen, JN = Jari Niemelä, AH = Annika Harlio, EP = Eeva Primmer, SP = Sari Pynnönen, AE = Ari Ekroos

1 Introduction

We are living in a global environmental crisis composed of numerous interlinked and complex environmental problems. Climate change and biodiversity loss are examples of wicked problems that have already crossed safe boundaries from the human viewpoint (Rockström et al., 2009). A trend of degrading environmental quality has been showed by scientific knowledge. Numerous science-based actions, including a number of global agreements, have been made with the purpose of enhancing the conservation of biodiversity and solving other environmental problems (Haas, 2004). Despite these agreements and other efforts, biodiversity degradation and decline still continue (Dirzo et al., 2014; Rassi et al., 2010; Tittensor et al., 2014) in spite of nature conservation being a commonly agreed on policy objective. Current efforts are mainly concentrated on specific places, e.g. establishing conservation areas, or on mitigating specific problems, but have lacked consideration of nature as a holistic and connected entity that produces benefits to people. Nature conservation effectiveness should be increased.

Effectiveness relates to the ability of shaping an agenda or advancing the state of a debate, and eventually improving the quality of the environment (Haas, 2004). The Merriam-Webster dictionary (2017) defines being effective as the ability to produce a desired effect. Thus effectiveness can be measured by comparing results to a policy objective. (Non-)effectiveness of nature conservation is the results of a non-linear policy process, which consists of deciding policy objectives, selecting policy instruments and implementing them in practice (Teisman, 2000; Pierre and Peters 2000, p. 42). However, various paradigms of what to conserve to reach effective conservation exist even within the fields of environmental sciences and ecology. For example, should the objective of conservation be ecological connectivity, or regionally rare species or habitats? Should the objective be to conserve ecosystem services, or biodiversity as such? Ecosystem services draws the attention to benefits and services that humans receive and obtain from nature (Millennium Ecosystem Assessment, 2003). Many scientific concepts are still evolving, are based on multiple or alternative theories, and can have various interpretations when tuned to practical actions. In addition to ecological knowledge, other forms of science and knowledge contribute to our understanding of environmental problems, e.g. knowledge from other natural sciences (e.g. climate change) or social science. Furthermore, the contribution of science to policy must be understood in relation to indigenous and local knowledge (Berkes et al., 2000; Fortmann and Ballard, 2011; Geertz, 2000; Yli-Pelkonen and Kohl, 2005). Local and scientific knowledge can be complementary (Berkes et al., 2000; Yli-Pelkonen and Kohl, 2005). Various knowledge types are present during policy processes.

Also other factors apart from evidence, such as competing interests and values, contribute to the policy process (Rose, 2015). The use of extensive scientific research on biodiversity and climate change in policy formulation and practice is not straightforward (Toomey et al., 2016; van Kerkhoff and Lebel, 2006). The impact of science is a compromise between the authority of science and other political interests (van Kerkhoff and Lebel, 2006). The interactions between science and policy is a dynamic arena of shared responsibilities within larger systems of different knowledges and power (van Kerkhoff and Lebel, 2006).

Environmental issues involve various actors, they define how the environment is used or not used and they are either directly or indirectly affected by environmental problems. Actors are present in different phases of the policy process and they also form the links between knowledge and action. The actors in this thesis are all human actors involved in nature conservation policy, including landowners, authorities, NGOs, companies and researchers. The stakeholder concept is often used to mean groups that are involved, but scientists and authorities are often excluded. Instead of stakeholders, I therefore use the concept of actors in this thesis. Actors' participation to environmental policy making (van den Hove, 2000) and even to knowledge production (Funtowicz and Ravetz, 1993) appears to offer effective tools for finding solutions to environmental problems. However, different actors hold different power possessions, which can complicate participation.

Ultimately the question of nature conservation is on balancing the options of utilizing nature and preserving it. Policy instruments are tools to reach policy objectives. In general, they can be classified as regulatory, economic instruments and information (Vedung, 1998). A broad spectrum of policy instruments exists, including top-down and voluntary approaches (Doremus, 2003; Kamal et al., 2014). Protected areas have traditionally been the most important nature conservation instruments. EU-level instruments impact national regulation, but additional regulation and other policy instruments can be in place at the national level. European-level regulation includes the Birds and Habitats Directives, which are implemented at the national level using the Natura 2000 network and other actions. National parks in particular are important for national-level nature conservation. In addition to increasing the quantity of conserved areas, their quality can be improved e.g. through restoration and management actions.

As the problems of narrow approaches in governing environmental and implementation difficulties have been recognized, efforts have recently been made to benefit from knowledge to combine existing policy instruments and to develop new approaches in innovative ways. Landscape and regional consideration of nature are important, but the role of nature conservation or enhancement is often still seen as secondary in land-use planning. Green infrastructure is a relatively new governance approach; it is holistic and multiscale, and presented as an essential element of the EU biodiversity policy as described in the latest EU Biodiversity Strategy (European Commission, 2011). It could be used as an instrument to implement holistic planning and for adapting to climate change (Mazza et al., 2011). It is defined as connected green (and blue) areas that produce ecosystem services (European Commission, 2011; European Environmental Agency, 2011; Mazza et al., 2011; Naumann et al., 2011; Salomaa et al., 2017). Voluntariness is another rising form of governance. Voluntariness as a tool towards nature protection and sustainability has gained popularity from the individual to global levels, and is manifested e.g. in consumer freedom of choice, UN-REDD programmes and the latest climate negotiations in Paris (United Nations, 2015). In Finland, the voluntary approach to conservation has gained popularity, especially because of the success of the Forest Biodiversity Programme METSO. For example, the Natura 2000 network, which was planned based on ecological effectiveness, has been criticized because of its disregard to the expectations, needs and cultural circumstances of landowners (Hiedanpää, 2002). The implementation of voluntary conservation requires the development of conservation plans, which consider the social constraints to achieving an ecologically optimal solution. The third rising approach, simultaneously highlighting ecological knowledge and participation was emphasized in Finnish peatland policy. Peatland policy is an example of tensions between natural resource use and preservation. Peat has economic value as an energy source, but on the other hand peat burning produces carbon emissions and peat extraction destroys biodiversity. Green infrastructure, peatland conservation policy and voluntary forest conservation are all nature conservation efforts that have tried to benefit from the current state of knowledge and from novel ways of combining existing policy instruments. All these approaches recognized the need to increase conservation efforts, utilize current ecological knowledge and a parallel need to gain social support for policy actions. Green infrastructure, peatland conservation policy and voluntary forest conservation offer insights to policy processes aiming for effective nature conservation. However, they are functioning in a world of various knowledge types, policy valuations and actors with different interests.

The dialogue between science and policy is changing simultaneously as environmental problems, the science related to them and societies change. The traditional way of conducting research, where knowledge is gained through single disciplines and then transmitted to policymakers, is not enough to sustainably manage biodiversity in complex socio-ecological systems. On the other hand, the use of science in politics is also changing. Scientific knowledge has been disregarded in international politics to an extent that we are claimed to be currently living in an era of post-truth politics (Lockie, 2017). When environmental problems are global, there are no simple and universal ways of realizing effective regulation and other instruments into action. Understanding the use of policy instruments at the state level is therefore necessary. In addition, conservation effectiveness could be improved by better understanding of the social dimensions connected to environmental issues (Bennett et al., 2017). I study the roles of actors in nature conservation and their perceptions, as they define nature conservation results and have knowledge of how its effectiveness could be improved.

2 Aims of the thesis

In this PhD thesis, I study actors' roles and perceptions on the opportunities to increase nature conservation effectiveness by focusing on interaction between knowledge and policy process. I focus on interaction between different knowledge types, and a policy process - deciding policy objectives, selecting and implementing policy instruments - to understanding how to improve existing practices and (not) develop new ones. I study topical nature conservation processes, which aim at combining existing instruments and developing new approaches in innovative ways. I use three cases in Finland: (1) new policy approach green infrastructure, (2) voluntary forest conservation and (3) conflicting peatland conservation policy.

I examine three more specific research questions:

1) How various interpretations of scientifically complex knowledge concerning nature (especially ecosystem services and ecological connectivity) affect selection and could affect the implementation of nature conservation policy instruments?

Two cases are used: new policy approach green infrastructure (Chapter I) and a conflicting peatland conservation policy (Chapter IV).

2) What types of knowledge are relevant to improve the effectiveness of (voluntary) nature conservation policy instruments, and how are they used during implementation?

I study this with a case of voluntary forest conservation (Chapter II).

3) How integrative knowledge can be produced for targeting (voluntary) nature conservation policy instruments?

I study this with a case of voluntary forest conservation (Chapter III).

This thesis consists of summary part and four research articles corresponding to four Chapters.

3 Theoretical framework

3.1 Approach

I consider the research questions based on empirical material aiming to find practice-relevant answers. I study the actors' viewpoint concerning nature conservation practices and processes and their roles in these processes. I aim at understanding the phenomena of interactions between science and policy process and have used a combination of multiple theories suitable for studying the cases. My approach to science-policy (and practice) interaction benefits from multiple scientific fields including conservation biology, seeing science as a form of knowledge among other knowledges, participation by policy sciences and policy evaluation (Toomey et al., 2016). My approach is interdisciplinary and pragmatic; the value of knowledge, whether rationalist or empirical, is judged with respect to understanding the research problem (Moon and Blackman, 2014). I aim for conceptual generalization of my results through the dialogue of various cases and by finding answers on how to increase the effectiveness of nature conservation in practice. In the next sections I present central components of nature conservation science and policy process interaction: effectiveness of nature conservation as a policy objective (3.2), different types of knowledge (3.3), various theoretical approaches of science-policy interaction (3.4) and policy process and policy instruments (3.5).

3.2 Effectiveness of nature conservation as a policy objective

The nature of environmental problems, i.e. long time frames, complexity, coverage of graphically remote regions and uncertainty of scientific knowledge (Mickwitz, 2003) make judging the effectiveness of actions difficult. Effectiveness of nature conservation means the capability of preserving nature. Conservation effectiveness can be measured e.g. in practical conservation planning by how reliably a conservation area network achieves its conservation objectives (Kukkala, 2017). Local perceptions on social and ecological impacts can be used as evidence to improve conservation (Bennett, 2016). However, what to conserve if the goal is gaining effective results, is not a simple question even within the field of ecology.

Nature can be represented in various ways, and various aspects can therefore be emphasized while interpreting conservation aims. For example, the focus can be either human- or nature-centric. Nature conservation effectiveness is not a simple question, especially when unequal aspects of nature must be prioritized. The knowledge-making process is part of a governance regime, and therefore, it is not irrelevant how knowledge present in policy processes represents nature (Turnhout et al., 2016). Various ecological aspects that can be emphasized include ecological connectivity, conservation of rare species or ecosystem services. Alternatively, non-ecological aspects can be emphasized in nature conservation: costs, avoiding conflicting locations, climate change and protection of private owners’ wealth. Considering the effects of climate change is required for effective conservation results, even if it would not be emphasized as a phenomenon of its own.

Nature conservation along with other policy objectives requires valuation. Correspondingly, science reflects values (Haas, 2004). Efforts to inclusively account for pluralistic values of nature’s contribution to people have been conducted in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Pascual et al., 2017). IPBES and numerous other science-policy interface platforms have recently risen to assess the current state of knowledge and to facilitate the interaction between science and policy (Tinch et al., 2016; van den Hove, 2007). In many respects IPBES had tried to learn the lessons from the Intergovernmental Panel on Climate Change, which is focused on assessments whereas IPBES has additional functions of knowledge generation, capacity-building, and policy support (Brooks et al., 2014).

It is possible to evaluate changes in nature as well as evaluate the qualities of a specific policy instrument (Mickwitz, 2003), but it is much more difficult to evaluate the outcomes of certain policies or to understand how policy could be transformed towards sustainable development. Comparing the impact of nature conservation policies to ecological knowledge is not the only reason why policies can be considered to have merit, worth and value (Mickwitz, 2003). Mickwitz (2003) proposes to focus on relevance, impact, effectiveness, persistence, flexibility, predictability, legitimacy, transparency and equity when evaluating policy instruments. This thesis aims to study opportunities for increasing the effectiveness of nature conservation. However, I do not try to measure impacts in nature myself, but study perceptions of actors on increasing the effectiveness of conservation policy instrument combinations, considering that other dimensions exist for evaluating the merits of these instruments.

Humans aim to understand and describe what occurs in nature to govern it effectively. Various ways exist for understanding nature, but the common understanding in western countries, where the general literacy and education levels are high, is based on science. In my research I aimed to have a holistic view of understanding nature (but from the western perspective). According to a commonly used definition, biodiversity consists of genetic diversity, species diversity and habitat diversity (Wilson, 1988). Often in practical contexts diversity is measured by species richness. Species rarity classifications affect policy, for example, species listed in the appendix of the Habitats Directive are strictly protected. Connectivity of habitat patches is important because loss and fragmentation of natural habitats causes declining biodiversity (Hanski, 2005; Rybicki and Hanski, 2013). Conservation of ecological connectivity illustrates ways to differently interpret ecological knowledge. Connectivity can be structural or functional, and these two are often correlated (Moilanen and Hanski, 2001; Tischendorf and Fahrig, 2000). Functional connectivity restricts or enables species dispersal, and is a species-specific attribute. Structural connectivity can be determined e.g. using a scale measuring the connectivity of conservation areas or green bridges over highways. Understandings of ecological connectivity have been divided into three major categories: species-specific habitat connectivity, spatial structure of vegetation cover and connectivity of ecological processes

(Lindenmayer and Fischer, 2007). The precise aim of connectivity should therefore be taken into consideration when planning actions using the connectivity approach.

The concept of ecosystem services, i.e. the benefits that humans gain and receive from nature (Millenium Ecosystem Assessment, 2003), is one way of attempting to increase the use of evidence in policy. In Millennium Ecosystem Assessment (2003) ecosystem services are divided into classes of provisioning, supporting, regulating and cultural services. The concept of ecosystem services has its roots in critique aimed at traditional economics, and reflects measuring the economic values of nature (Costanza et al., 1997; Dempsey and Robertson, 2012). The Millennium Ecosystem Assessment (2003; 2005) was the most influential initiative to mainstreaming the ecosystem services concept. Later the classification was revised to emphasize the economic benefits of biodiversity, especially influential was a global initiative The Economics of Ecosystems and Biodiversity (Kumar, 2010) and to develop to an accounting system of ecosystem services (CICES, European Environment Agency, 2016). Natural capital is a related concept, used for example to show that nature has a fundamental role in economic output (European Commission, 2011; European Environmental Agency, 2016). The use of ecosystem services and related concepts has been criticized, especially because of their utilitarian view (Schröter et al., 2014; Vira and Adams, 2009). However, the ecosystem services concept has become a key element of mainstream environmental policy (Redford and Adams, 2009). This is reflected also in the name of IPBES, however interestingly IPBES has started to use a concept of nature’s contributions to people to allow more pluralistic understanding of nature (Borie and Hulme, 2015; Pascual et al., 2017).

Measuring ecosystem services often involves valuation, e.g. monetary valuation, as various services are not commensurate. Different tools, such as spatial prioritization, are founded on ecological knowledge and can be used to guide conservation implementation. Such tools and ways of measuring largely determine how implementation of the policy impacts nature. Ambiguities of policy objectives, for example ecosystem services, may be hidden behind scientific methods that are assumed objective (Lennon, 2015a). Although these methods are developing rapidly, numerous existing methods mainly allow the monitoring and assessment of the most tangible ecosystem services, i.e. provisioning services (Primmer and Furman, 2012). The expansion of cities poses challenges to the provision of ecosystem services, therefore it is important to consider them in the urban context (Niemelä et al., 2010). However, if human proximity is the main criteria, nature areas that are further from cities and probably closer to a natural state may be seen less important than areas closer to people. Considering a wider spatial scale is also important for understanding ecosystem functioning.

Although biodiversity and ecosystem services are holistic per se, biodiversity is often restricted to species diversity and ecosystem services are vaguely defined in practical conservation. I wished to broaden these narrow ways of interpreting concepts. Therefore I have used a concept of ecologically functioning nature, especially in the peatland case (IV), to be able to separate inadequate interpretations of nature from a view that could preserve functions of nature. Ecologically functioning means a holistic view on preserving biodiversity, for example when considering networks, ecological connectivity, water catchment basins and large areas, because the loss and fragmentation of natural habitats cause declining biodiversity (Hanski, 2005; Rybicki and Hanski, 2013).

3.3 Different knowledge types

In this thesis I try to understand the roles of different knowledge types as contributing to the effectiveness of nature conservation. Highlighting the roles of various knowledge types responds to the concerns of the utility, validity and legitimacy of using the linear model in science-policy interaction (Pregernig, 2014). Multiple overlapping ways exist for categorizing knowledge (e.g. Raymond et al., 2010), some of which I explain next.

My research approach is interdisciplinary which means combining multiple scientific disciplines. The modes of scientific knowledge can be divided into basic, applied and transdisciplinary research (Hadorn et al., 2008). Transdisciplinary research aims: "to grasp the complexity of the problems, to take into account the diversity of scientific and societal views of the problems, to link abstract and case specific knowledge, and to constitute knowledge with a focus on problem-solving for what is perceived to be the common good." (Hadorn et al., 2008). According to this definition, my research could be defined as transdisciplinary. However, often in transdisciplinary research the input from non-academic stakeholders is even stronger than in this thesis and therefore interdisciplinarity concept is more suitable. When simultaneously considering various scientific disciplines, it is important to take their differences into account.

Different sciences study nature and some of them produce ecological knowledge, e.g. ecology, biology, conservation biology and forest ecology. These natural sciences have been quite dominant in developing nature conservation in the past. Conservation science has recently grown into a meta-discipline that increasingly integrates social sciences, for example sociology, anthropology and psychology (Moon and Blackman, 2014). The contribution of social sciences to conservation can be descriptive, diagnostic (why actions have succeeded or failed), disruptive, reflexive, generative, innovative or instrumental (Bennett et al., 2017). In addition, the fields studying climate change are especially relevant fields of natural (and social) sciences in the context of current environmental policies. Ontology, epistemology and philosophical perspective differ between the natural and social sciences (Moon and Blackman, 2014). Understanding how the principles and assumptions of various disciplines differ is necessary for combining them, especially as natural sciences have a prevailing positivist approach (objective knowledge can be generated by observations) and do not have traditions in reflecting various philosophical assumptions (Moon and Blackman, 2014).

Local and indigenous knowledge are often used to refer to knowledge that indigenous people possess. Their knowledge is essential for global biodiversity conservation, because they live in and manage large and often biodiverse areas (Tengö et al., 2017). Traditional ecological knowledge includes local practices for managing ecosystems (Berkes et al., 2000). Local ecological knowledge can be also used as concept to describe for example nature enthusiasts' and local residents' lay-expert knowledge in western context (Yli-Pelkonen and Kohl, 2005). A person's local knowledge can merge with scientific knowledge (Fortmann and Ballard, 2011; Yli-Pelkonen and Kohl, 2005). Knowledge is often site specific (Spilsbury and Nasi, 2006). In Chapter II, local knowledge is related to local places, people and organizations. Local knowledge is acquired, possessed and applied by local actors. It can relate e.g. to local biodiversity patterns, local institutions, such as attitudes and customs, or local socio-ecological history.

Alternatively, knowledge can be classified as scientific, bureaucratic (administrative) and stakeholder knowledge (Edelenbos et al., 2011). Interaction between science and policy can be studied by separating actors groups and their knowledge, e.g. scientists, policymakers and other actor groups. However, I do not do so because the same person can have several roles. However, I acknowledge that different actor groups act with different time scales and constraints and in different contexts. In Chapter II, expert knowledge refers to knowledge gained while holding an expert position such as forest adviser or authority. The concept of coproduction of knowledge has been used at least in two meanings: 1) science, governance and social, cultural and political norms interact with each other or 2) to describe the integration of different actors' knowledge which leads to a common knowledge ground (e.g. van Kerkhoff and Lebel, 2015; Edelenbos et al., 2011; Jasanoff, 2004).

Knowledge can also be functionally different. It can be divided along varying continuing dimensions, e.g. locality, formality, expertise, accessibility and embeddedness in traditional cultures (Raymond et al., 2010). Knowledge can also be divided into various hierarchies e.g. from exact data to heuristics and policy recommendations. Categorizing knowledge does not give justice to the ways in which people learn, understand new information (in the context of their personal understanding) or how context influences how people understand something (Raymond et al., 2010). However, different types of knowledge are applied during different phases of the policy process and making them visible may help finding opportunities for increasing nature conservation effectiveness. Different actors hold different types of knowledge that are relevant when considering the link between knowledge and policy instruments. In practical situations various knowledge types exist simultaneously, and they can also be purposefully integrated when aiming for more effective conservation results.

3.4 From a gap between research and implementation to interaction between science and the policy process

My study is situated in a wider framework of science-policy (and practice) interactions. Interaction between knowledge and action can be studied from various angles (Pregernig, 2014; Toomey et al., 2016). Instead of single framing, science-policy interaction should be discussed in a more frame-reflective way to produce more impactful advise (Pregernig, 2014). Different theories point to different solutions (Pregernig, 2014). In my research I begin with the concept of research-implementation gap, and justify why it alone is not the most effective conceptualization.

The phenomenon of not implementing scientific knowledge in practical actions has been called the research-implementation gap (Knight et al., 2008; Pullin and Knight, 2003;

Sutherland et al., 2004). The research-implementation gap concept has been used e.g. when researchers have selected a network of priority conservation areas by utilizing scientific methods, but the network has not been implemented in practice (Knight et al., 2008). Evaluations, syntheses and recommendations based on existing scientific knowledge are at the heart of suggestions to fill the gap with evidence-based policy or actions (Pullin and Knight, 2003; Sutherland et al., 2004). This view is in accordance with the traditional science transfer model, where the transfer of science to policy is considered linear. Although criticized, this view still has support, especially in conservation biology.

The conventional model of science trickling down to action has been criticized e.g. because it does not consider that science is socially embedded, socially constructed, because there is no strict boundary between science and society, and because it undervalues power (van Kerkhoff and Lebel, 2006). Describing the link between knowledge and action to be emerging through participation, integration, negotiation and learning has been used to address the critique aimed at the conventional knowledge transfer model (van Kerkhoff and Lebel, 2006). For example, Böcher (2016) highlights that integration between research and its use works both ways. The concept of evidence-based policy has later been widened to a concept of evidence-informed conservation by Adams and Sandbrook (2013). They suggest that the definition of evidence should be broadened to include qualitative data and local knowledge, and the complex policy process should be addressed more thoroughly. Toomey et al. (2016) have suggested reconceptualization as a space between research and implementation, which recognizes conservation to be a social process that engages science, and that persons and ways of doing and knowing exist in specific contexts even without science.

Communication theory considers science-policy interaction as an (ineffective) transfer of science to policy through communication. Particularly the degree of uncertainty inherent to scientific results and the use of scientific language to report results cause difficulties in the uptake of research among policymakers (Pregernig, 2014). It is not the lack of information, but the sheer amount that makes it difficult for policymakers to gain an overview of scientific knowledge (Janse, 2008). Additional challenges are posed by differing time scales of science and policy. Furthermore, policymakers and scientist may have varying views on what kind of research or information is important (Janse, 2008). Cash et al. (2003) and Cook et al. (2013) argue that to be effective, science should be clear, relevant and fair. Another view of framing interaction between science and policy is the indirect utilization of research (Young et al., 2014). For example, implications of utilizing the ecosystem services and green infrastructure concepts in policy are indirect and dependent on how actors use these concepts (Cowell and Lennon, 2014; Jordan and Russel, 2014; Lennon, 2015a, 2015b).

Participation of various actors poses multiple advantages as well as limitations. Participation in decision-making increases legitimacy and indicates a normative shift towards recognizing multiple values (Appelstrand, 2002). Legitimacy relates to the perceived fairness and acceptance of policy institutions, procedures and outputs. Participation relates to procedural justice (fair participation in decision-making), and distributive justice (impacts on well-being). Advantages of participation to environmental projects include improving design by local knowledge, more successful implementation, integration of various interests, and social learning (Luyet et al., 2012). However, participatory approaches challenge the dominance of natural sciences as the foundation of environmental policymaking (van Kerkhoff and Lebel, 2006). Other risks of participation include higher costs, longer time frame, frustration, showing new conflicts and unbalanced representation (Luyet et al., 2012). Notably, natural sciences can also offer participatory ways for producing science, such as participatory field inventories. Stakeholder participation in conducting science, also called as a post-normal science, is understood to increase the understanding of environmental problems when uncertainties and decision risks are high (Funtowicz and Ravetz, 1993).

Yet another dimension to interaction between science and policy comes from considering power. Viewing science as a strategic resource accounts power issues that are inherent to policy (Pregernig, 2014). Various actor groups may have different interests and various levels of power to influence decisions. Policy solutions are defined by the most powerful actors (Juntti et al., 2009). Certain knowledge types mobilize society and resources in a specific way, whereas other types may mobilize other kinds of actions. Knowledge thus exercises epistemic power (Turnhout et al., 2016).

Overall, translating science into policies is a complex process compromising between the authority of science and other interests (van Kerkhoff and Lebel, 2006). The understanding of relationship between science and governance has changed from an idea of an existing gap to the idea of interconnectedness and interplay (van Kerkhoff and Lebel, 2015). Van Kerkhoff and Lebel (2006) have proposed that the relationship between science and action should be understood as a dynamic arena of shared responsibility within a larger system of different knowledges and power. Relationships between science and governance are contextualized, dynamic and dependent on relationships between actors (van Kerkhoff and Lebel, 2015). These conceptualizations of knowledge and policy process interactions is closest to the conceptualization of interaction discussed in this thesis, which I aim to deepen through empirical cases.

3.5 Policy process and policy instruments

Policy processes can be conceptualized with different models including the phase model, the stream model and the rounds model (Teisman, 2000). The general phase model of policy process includes phases of consideration, decision, implementation and evaluation (Jenkins, 1978 p. 17) or in other words, policy formulation, adoption, implementation and evaluation (Teisman, 2000). Each of these phases has own characteristics and actors (Teisman, 2000). Consideration on how government can steer society effectively can be approached by focusing on policy instruments (Pierre and Peters 2000, p. 41). Policy instruments approach sees (non-)effectiveness of nature conservation as the result of a policy process, which consists of deciding policy objectives, selecting policy instruments and implementing them in practice (Pierre and Peters 2000, p. 42) (Figure 1). These phases are not linear, but can be separated. Phase model assumes that decision-making is problem oriented and it pays attention to a focal actor, often central government (Teisman, 2000). The phase model is used in this thesis because it helps revealing dynamics of nature conservation oriented (or not) policy process and ways central actor organizes (or not) policy process i.e. the dynamics towards effective nature conservation.

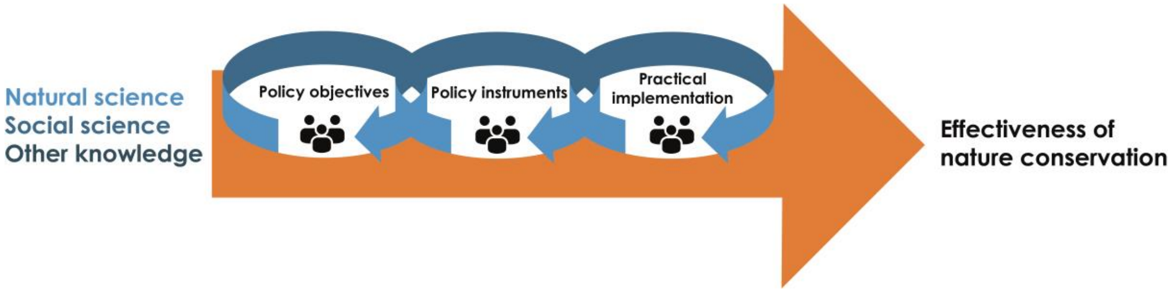

Figure 1 Interactions between knowledge types and policy process create opportunities for the effectiveness of nature conservation. Different knowledges (blue lines) interact during the policy process, which consists of deciding on a policy objectives, selecting policy instruments and implementing them in practice. Actors create interactions between knowledge and different phases of policy process.

Policy instruments can be classified as regulatory, economic and information (Vedung, 1998). Environmental policy can be advanced through several instruments; they can prevent actions that alter nature, decrease harmful effects or improve the state of nature. In nature conservation, policy instruments can be e.g. various types of conservation areas or subsidies. Various policy instruments form combinations that work together (Doremus, 2003). Considering a combination of instruments is crucial for nature conservation effectiveness, because by definition single instrument typically do not consider ecological connectivity or have a holistic view on nature.

The Habitats and Birds Directives form the foundations of the EU biodiversity policy. EU has set its biodiversity targets for 2020 in its Biodiversity Strategy 2011–2020 (European Commission, 2011). Instruments and actions listed in the EU Biodiversity Strategy include fully implementing the Birds and Habitats Directives, restoring ecosystems, maintaining ecosystem services, strengthening green infrastructure, increasing contributions of other sectors, especially agriculture, forestry and fishery, and combatting invasive species. Traditional EU policy instruments were based on command and control legislation, but voluntary instruments have become more common (Jordan et al., 2003). EU directives have direct relationship to national-level regulation, but less-binding EU policies also affect national-level actions.

Policy instruments have varying regulatory strictness, ranging from voluntary to compulsory. Voluntary approaches can include binding instruments, but participation to conservation is voluntary (Kamal et al., 2014). This adds complexity and uncertainty to the implementation, which is characterized by involving various actors and their decisions. If landowners oppose centrally designed conservation plans, voluntary contracting can increase the acceptance of conservation, because it respects landowner autonomy over land-use decisions (Paloniemi and Tikka, 2008; Paloniemi and Vainio, 2011). For example, implementation of the Natura 2000 network has caused resistance in Finland (Hiedanpää, 2002). Voluntary conservation on the other hand is socially more acceptable (Kamal et al., 2014). Voluntary conservation is thought to increase conservation acceptance by respecting freedom of choice, involving diverse actors in knowledge coproduction and policy implementation processes. However, one of the challenges of the voluntary approach is that it may not allocate conservation resources efficiently (Doremus, 2003; Mönkkönen et al., 2009) or may not succeed to achieve sufficient conservation objectives (Kamal et al., 2014). Legislation has binding effects, but it is not always considered acceptable; hence there is potential contradiction when implementing nature conservation legislation.

4 Materials and Methods

4.1 Methodological approach

I have studied three different cases illustrating various aspects of interaction between different types of knowledge and policy (and practice) (Figure 2). Studying cases through and with actors unveils their perceptions, which consist of knowledge, values and attitudes. Chapter I focuses on the interpretations of ecological knowledge and its implementation with green infrastructure policy instruments. Chapters II and III focus more on knowledge types in practical context, and they discuss the Forest Biodiversity Programme. Chapter IV focuses on the representation of nature, participation and a wide variety of policy instruments in peatland conservation policy.

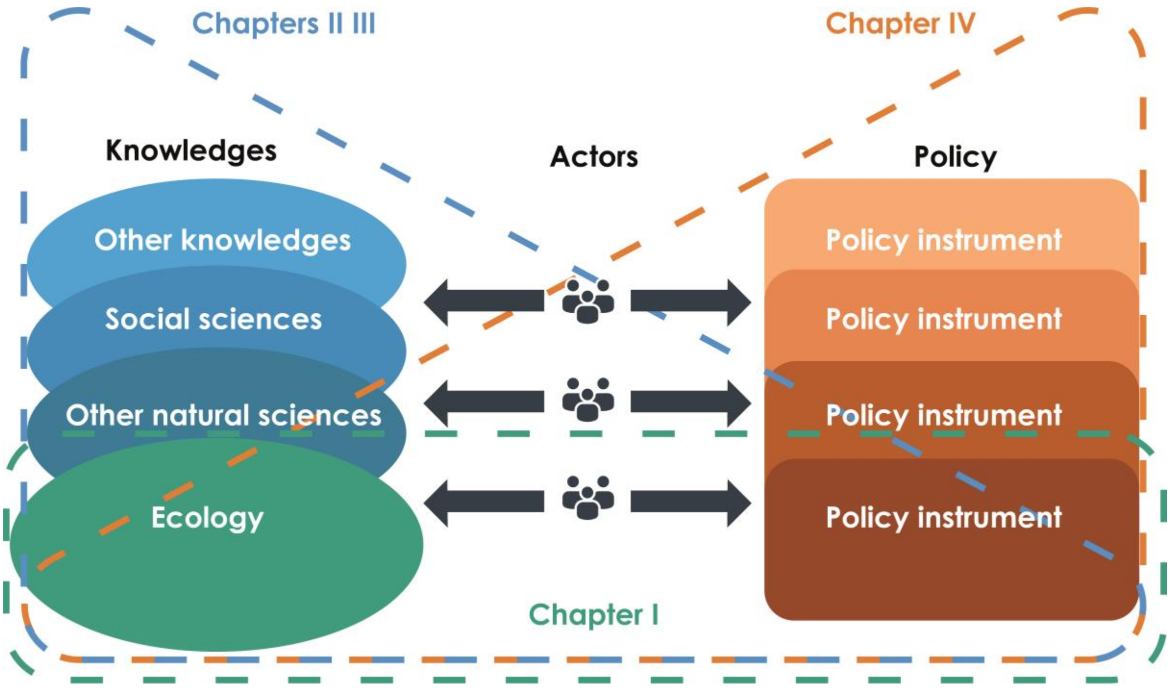

Figure 2 Methodological framework for the Chapters (articles) in this thesis: interaction between different types of knowledge and policy happens through actors. Chapters I (green line) consider interpretations of ecological knowledge and policy instruments. Chapters II and III (blue line) focus more on various types of knowledge than policy instruments, whereas Chapter IV (orange line) focuses more on various conservation policy instruments, and fewer knowledge types.

The cases I have examined are from Finland and include the main habitat types of the Finnish landscape. Forests and peatland make up the majority of Finnish green infrastructure. The cases are therefore not separate case studies, but different focuses of the same main context – Finnish nature conservation policy. Thus policy instruments discussed in this thesis are inevitably from the same pool of instruments used in Finland and the actor groups are overlapping (sections 4.2. and 4.3, Table 2 and Table 3). Although the cases are from Finland, the interaction of knowledge and policy process is a phenomenon with international relevance. Interaction of various knowledges and policy process is approached from different angles. The design of this thesis allows aiming for some level of conceptual generalization through the dialogue of various cases. However the cases are not strictly case studies in the sense they would all use a case study methodology, but together they form cases of the same context. A case study investigates a contemporary phenomenon or chain of events in depth drawing on all possible sources and methods and with a context to which the boundaries of the phenomenon might not be clear (Laine et al., 2007; Yin, 2014 p.16). The reason for conducting a case study is to understand a real word case and the major focus of case study can be e.g. decisions, individuals, organizations, neighborhood, institutions or events (Yin, 2014). A case study is a thick description (Laine et al., 2007). Chapter IV goes closest to the definition of a case study, but it also has emphasis on document analysis.

The main interest is in increasing the effectiveness of biodiversity conservation, but Chapters I, II and IV study some linkages to climate change to include some of the interactions between various environmental problems. Social aspects are also considered. Chapter I deals with implications of emphasizing different policy objectives to possible future implementation, Chapters II and III consider practical implementation and Chapter IV considers the various phases of the policy process: deciding policy objectives, selecting policy instruments and implementing them in practice (see different phases of policy process, Figure 1). However, these cases do not cover all possible emphasizes and options studying topical Finnish conservation policy events.

Various theories, data sets, analysis methods and researchers triangulate in the Chapters of this thesis (Table 1). Triangulation means that data, methods, researchers and/or approaches complete each other (Laine et al., 2007). Triangulation deepens the empirical and conceptual understanding of the various aspects of a case (Laine et al., 2007). Integrating qualitative and quantitative elements by using mixed methods to form coherent research is desirable, as it can evoke new ideas (Johnson and Onwuegbuzie, 2004; Tapio et al., 2011). Research benefits from the collaboration of multiple researchers, as it enables the in-depth analysis of more aspects than any researcher could perform alone. Because the Chapters of this thesis are not single-authored, I refer to the methods and results using subjective pronoun we.

Table 1. Triangulation used in summary part and in the various Chapters to deepen the understanding of the research questions.

Triangulation	Summary	Chapters			
		I	II	III	IV
Various types of data	X	X		X	X
Various analysis methods	X	X		X	X
Various researchers	(X)	X	X	X	X
Various theoretical approaches	X	X	X	X	X

I have used several methods to gain better understanding of the research questions. The data for analysing the green infrastructure study (I) were collected from a survey clarifying the views of experts. Analyses methods were qualitative and quantitative: repeated measures ANOVA, cluster analysis and content analysis. The focus groups data of the first forest conservation study (II) were analysed using content analysis. Content analysis of the focus groups was combined with prioritization of ecological and social data (landowners' willingness to participate) in the second forest conservation study (III). We also combined several data and analyses methods in the peatland case (IV) by using the case study approach involving participant observation, following events by examining several sources, studying legislation and conducting content analysis of policy documents.

In the next sections I will introduce the study cases (4.2.), data (4.3.) and analyses (4.4.) in more detail.

4.2 Cases

My study cases are 1) a new policy approach green infrastructure, 2) voluntary forest conservation and 3) conflicting peatland conservation policy. Considering nation-wide and continent-wide spatial scales is important for conserving ecosystem functioning. Green infrastructure, i.e. green multifunctional areas that are connected, could be used as an instrument to implement holistic multi-scale planning from the EU level to the regional level. Green infrastructure also helps in adapting to climate change e.g. by managing flood risks (Mazza et al., 2011; Wright, 2011). Green infrastructure aims at linking existing scientific knowledge (e.g. importance of connectivity and the size of areas, timely ecosystem services) and knowledge of previous implementation challenges (e.g. making benefits of nature visible, communicating across sectors), and thus increasing the effectiveness of nature conservation. Sometimes green infrastructure is divided into green and blue infrastructure. This thesis covers some blue elements, but the main focus is on terrestrial ecosystems and wetlands, not on lakes or sea. Ecosystem services and ecological connectivity are concepts central to green infrastructure implementation. Because green infrastructure has numerous meanings and its implementation is still under discussion, it is important to consider the opinions of researchers and practitioners to evaluate its role in biodiversity conservation.

Forests cover 75% of the land area in Finland. Voluntariness has been emphasized in Finnish nature conservation policy through The Forest Biodiversity Programme METSO (Government of Finland, 2014, 2008; Paloniemi and Varho, 2009). The Programme aims to halt biodiversity loss in southern Finland by involving private landowners, who own 60% of the productive forestland in Finland (Finnish Official Statistics, 2015). Voluntariness has created a need to work in collaboration with various actors. Participatory decision-making should increase legitimacy via procedural justice, but participation simultaneously challenges policy objectives that are based on natural sciences knowledge (Appelstrand, 2002; van Kerkhoff and Lebel, 2006). Therefore, voluntariness highlights the need to pay more attention to the variety of knowledges and their integration for more effective results than when using control and command instruments. Improving the effectiveness of voluntary biodiversity policies requires considering various actor perspectives on social constraints and opportunities.

Approximately one third of Finnish land cover is peatland. The definition of a peatland is broader than that of mires: peatland is land with a surface layer of peat and which is over 30 cm thick. Peatlands can be divided into various habitat types, some of which have forest cover. Peatlands are important for both halting climate change, because they are carbon storages, and for biodiversity conservation. Simultaneously peatlands are of interest of industry, which leads to encountering of competing interests regarding the use and conservation. Forestry and peat extraction for fuel are the current main economic uses. Peat extraction has caused conflicts between industry and nature NGOs concerning water quality and biodiverse areas (Jokinen et al., 2016). NGOs vigorously oppose peat extraction, which on the other hand has vocal and well-funded advocate groups. Peat extraction companies have strong ties to the national farmers' association the Central Union of Agricultural Producers and Forest Owners and the political Centre party. We studied peatland conservation in Finland in 2009–2015, during which peatland policy underwent intense changes. Policy documents were prepared with a differing working groups and also political power changed. Notably, a preparation of a new Peatland Conservation Programme was initiated, but the Minister of the Environment changed in the middle of the planning process, resulting stopping the preparation (and continuation with different means). The role of actors in developing policy, the resulting representation of nature, and selected and implemented policy instruments formed a complex and interesting puzzle.

A combination of policy instruments are covered in each of my study cases, i.e. green infrastructure, the Forest Biodiversity Programme and the peatland conservation policy (Table 2). In our empirical research design in Chapter I, we formed instrument groups from the already existing instruments that could be used when implementing green infrastructure: connectivity enhancing instruments (buffer zones and corridors), core area instruments (protected areas) and land-use planning instruments. Chapters II and III are from the same research project and involve a similar context of instruments. The Forest Biodiversity Programme's main conservation mechanism involves forest owners offering land for conservation as protection sites that are evaluated against ecological criteria. If the criteria are met, the land can be conserved permanently (either sold to the state or as a private conservation area) or temporarily. Environmental subsidy agreements and nature management projects are also actions promoted under the umbrella of the programme. The programme is planned to account for both people and nature (Paloniemi and Tikka, 2008), and therefore it also includes actions and funding that improve the knowledge base and communication, and enhance collaboration. Peatland conservation in Chapter IV utilizes many of the same instruments as mentioned above, especially spatial planning, the Peatland Conservation Programme, the Environmental Protection Act, the Forest Act, the Forest Biodiversity Programme and restoration.

Table 2. Various policy instruments studied in the different Chapters.

Policy Instruments	**Chapters**		
	I	II & III	IV
Environmental Protection Act (527/2014)			X
National parks, Natura 2000 sites, old conservation programmes	X		X
Private permanent protected areas*	X	X	X
Private temporary protected areas		X	X
Land-use planning (Land Use and Building Act 132/1999)	X		X
Environmental subsidies: restoration, management		X	X
Connectivity enhancing instruments (buffer zones, corridors)	X		
Communication and collaboration		X	

*land sold to state or privately owned conservation area

4.3 Data: studying cases through and with actors

The different Chapters involve various actors and centre on different but overlapping actor groups: biodiversity expert groups (Chapter I), different forest actor groups (Chapter II), forest actors with emphasis on landowners (Chapter III), and peatland policy actors (Chapter IV) (Table 3). The participation intensity of the various actors varied in our cases: the surveys and few one-on-one meetings in the peatland case correspond to the consulting level, while the focus groups were a way of more deeply involving the actors (Durham et al., 2014).

Table 3. Central actor groups studied in the various Chapters. See more detailed descriptions in the original articles.

Actor groups	Chapters			
	I	II	III	IV
Landowners		X	X Emphasis	X
Ministry of the Agriculture and Forestry		X	X	X
Ministry of the Environment				X
Environmental authority (especially ELY Centres)	X	X	X	X
Forest authority (Metsähallitus and Forest Centre)	X	X	X	X
Forest Management Associations	X	X	X	
Energy sector advocacy organizations				X
Private sector	X	X	X	
Political parties				X
Regional council	X	X	X	X
Nature NGOs	X	X	X	X
Natural scientists	X	X	X	X
Social scientists and interdisciplinary scientists	X	X	X	

We involved various actors in our studies in an attempt to also increase the practical relevance of our research and to improve the knowledge flow both ways between science and conservation practices. Especially, the research project in which voluntary forest conservation cases were conducted (Knowledge, communication and targeting of biodiversity conservation[1]) had aims to be interactive and advance the use of the findings: e.g. we organized field trips where some of the results were presented (Figure 3), published articles for lay people and posted on social media pages. Dialogue is needed when dealing with the field of environmental policy. This dialogue advances the understanding of decision-makers concerning the limitations of science and scientists' in understanding the problems faced by practitioners. Stakeholder participation increases the shared understanding of complex problems.

Figure 3 Field trip to Rekijokilaakso. In this location, we organized focus group discussions before the field trip. Researchers also presented some of the results in the field trip. Photo: Anna Salomaa.

[1] *Tieto ja vuorovaikutus monimuotoisuuden turvaamisen kohdentamisen tueksi. The project was lead by the Finnish Environment Institute (SYKE), More information: www.syke.fi/projects/BDtargeting*

In the green infrastructure case (Chapter I), we collected researcher and practitioner views (especially authorities, scientists, nature NGOs, private sector) through an expert survey concerning the possible implementation of green infrastructure policies in Finland. Their opinions on green infrastructure can shape and be used to evaluate its role in biodiversity conservation, as these actors have knowledge of various aspects relevant to green infrastructure implementation and have been involved in the designation of relevant policies and implementation guidelines. The expert survey is a way of simultaneously studying the concept and the underlying patterns of perceived successful nature conservation policy. We sent a questionnaire to 214 professionals from the following areas: Uusimaa, Southeast Finland, North Savo, Pirkanmaa and North Ostrobothnia, 47 of which responded. In the quantitative part of the survey, respondents evaluated statements using a Likert scale and policy instruments using an interval scale. We also used one open question.

In the forest case (Chapter II), data were collected during nine focus group discussions involving a total of 59 forest conservation actors. Landowners, forest advisers, scientists, forest and environmental authorities and other actors influence the success of voluntary conservation. Discussions were organized in Rekijokilaakso, Southwest Finland; Joensuu, North Carelia and Virrat, Pirkanmaa (where participants also represented Southern Ostrobothnia). Participant selection was based on nominations from regional experts and on snowball sampling (Noy, 2008). Focus groups presented the combined views of various actor groups. Localized statements systematically covering various aspects of policy instrument values (policy evaluation criteria by Mickwitz, 2003) were used as a corpus for the discussions. Policy evaluation criteria were used to make various knowledge types visible (Figure 4).

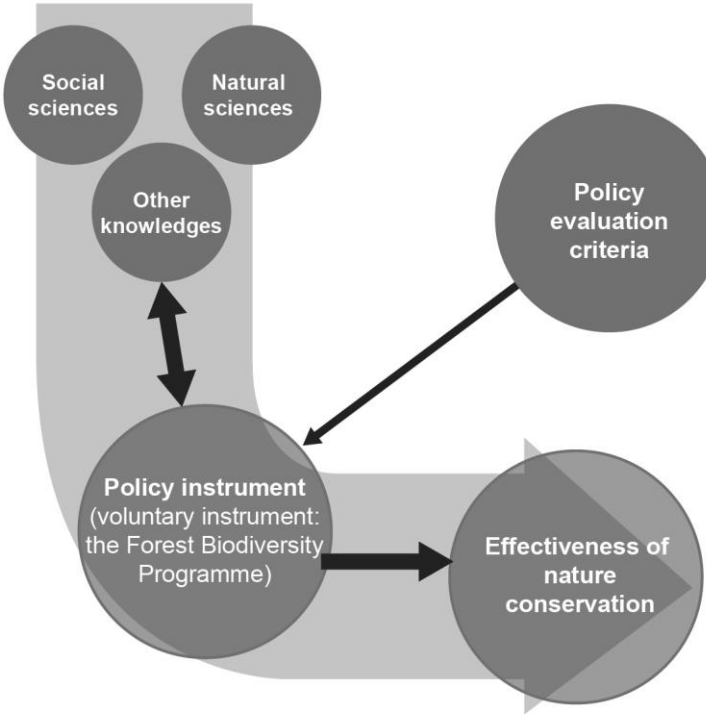

Figure 4 We studied how the effectiveness of nature conservation policy could be increased (wide arrow). We assume that scientific knowledge and experiences of forest actors intertwine when implementing voluntary conservation, and that effectiveness can be enhanced by understanding the phenomena linked to the use of sciences and other knowledge in implementation. Policy evaluation criteria were used to elicit opinions on various aspects that the policy instrument values consist of Figure from Chapter II (Salomaa et al., 2016).

In the second forest case (Chapter III), we combined data from a landowner survey, spatial conservation prioritization and focus groups. We used Rekijokilaakso as an example area during the spatial prioritization. The landowner survey was a questionnaire sent to 2200 randomly sampled and systematically selected forest owners, 509 of which responded. The study areas Rekijokilaakso-Hyyppärä, Pirkanmaa, Southern Ostrobothnia and Northern Carelia were selected to cover a spectrum of social and environmental contexts. The questionnaire was complemented with 32 new responses in the spatial prioritization area (Rekijokilaakso). Respondents evaluated statements on biodiversity conservation by importance and on a scale. Ecological data for prioritization consisted of national forest inventory data from Finland and the Finnish national survey on the biotopes of wooded seminatural grasslands (Vainio et al., 2001; Tomppo, 2006). Weights and connectivity parameters were based on Lehtomäki et al. (2009). My responsibility in Chapter III was within the focus group design, which was the same as in Chapter II.

We used a case study approach (Laine et al., 2007) in the peatland case (IV). Three central policy documents were the main data (Peatland Strategy, Ministry of the Agriculture and Forestry, 2011; Government Resolution, Government of Finland, 2012, and Proposal for Conservation Programme, Alanen & Aapala, 2015). We also followed peatland policy development, used participant observations, and studied the content of relevant Finnish legislation. We focused on actors who have participated in forming the policy documents (Ministries, environmental authorities, scientists, nature NGOs, energy sector advocacy organizations). We also discussed with the actors (authorities, researchers) that had participated in the peatland policy formulation.

4.4 Analysis methods

I have used qualitative and quantitative methods to gain a holistic understanding of the interactions between knowledge and policy process. Various methods support each other in three of the Chapters (I, III and IV), and overall in this thesis. In Chapters I and III both qualitative and quantitative data were used within the same study and both had quantitative emphasis. Mixed methods means mixing of qualitative and quantitative approaches, data, methods or methodologies, within a research study (mixed methods see Johnson and Onwuegbuzie, 2004). On the other hand, Chapters II and IV used qualitative approach.

We used content analysis in each case. It was used to complement the quantitative part of the green infrastructure case (Chapter I). Interpretative qualitative content analysis of the focus groups was used as the only method in the first forest conservation case (Chapter II). We found categories reflecting phenomena that are relevant to knowledge use and summarized the relationships of the most important actors. In the second forest case (Chapter III) we performed a content analysis on aspects related to conservation planning using the same data. In the peatland case (Chapter IV), we used the case study methodology based on different materials. Our analysis had an interpretative tone aiming for a thick description of the case. We used policy documents as the main data. We described the development of participation and the resulting representation of nature in three policy documents, and proposed and implemented conservation policy instruments during a policy process. We also examined the main changes of environmental legislation. With both the forest and peatland cases we began by coding and used qualitative analysis software (NVivo in Chapters II and III and Atlas.ti in Chapter IV) when performing the analysis.

We used several quantitative methods. We used hierarchical cluster analysis and repeated-measures analysis of variance (ANOVA) as the quantitative analyses methods during the analysis of the green infrastructure case (Chapter I). Content analysis was combined with prioritization of ecological and social data in the second forest case (Chapter III). The landowner survey was analysed with exploratory factor analysis. A factor representing willingness to participate in conservation actions which are coordinated at the landscape level, was used as one data layer in the spatial conservation prioritization. Three spatial prioritization analyses were performed using the Zonation software: these were based on 1) ecological data only, 2) ecological data and landowner perceptions and 3) ecological data with removal of landowners that were negative towards conservation.

5 Results

5.1 Interpretations of science affect selection and could affect the implementation of policy instruments (I, IV)

We studied how various interpretations of scientifically complex knowledge concerning nature affect the selection and could affect the implementation of nature conservation policy instruments in the case of a new policy approach (Chapter I) and in conflicting policy (Chapter IV). We found that the objective of providing ecosystem services was perceived to differ from the objective of biodiversity conservation, and both were considered important in the possible future implementation of green infrastructure (a combination of policy instruments). In peatland case, the representation of nature changed from arguably politically coloured use of ecosystem services to comprehensive and detailed ecological knowledge. However, simultaneously political power changed and implementation of policy instruments diverged from scientifically justified need for conservation. Using the ecosystem services concept to make nature's value more visible might help to integrate nature into various policy sectors. However, biodiversity conservation might be compromised if focusing only on ecosystem services.

Both ecosystem services and ecological connectivity can be interpreted in various ways, which might leave room for different ways of implementation. Our research discussed multiple alternative definitions of ecological connectivity (e.g. structural and functional) and showed that interpreting ecosystem services can be skewed e.g. because of possible difficulties in measuring them (e.g. using only monetary measures). Ambiguity of the green infrastructure concept, to which both ecological connectivity and ecosystem services are central, creates obstacles for practical implementation, even if this ambiguity might have helped the approach gain political approval. Different understandings will challenge policy makers and practitioners to open the different interpretations of the concept, in order to facilitate better cooperation and dialogue between science and practice. Strengthening existing biodiversity conservation instruments is as an integral part of developing a green infrastructure policy, and crucial for effective biodiversity conservation. Our results described the potential interaction and dynamics that the green infrastructure approach could bring to environmental policy, but also reflect that green infrastructure has currently not been systemically implemented in Finland, and therefore the extent or direction of change remains unclear.

Nature was represented differently in three peatland policy documents (Figure 5), which were prepared with partly differing groups. The actors had variety of opinions of peat use, varying from strict conservation to strongly for peat extraction, and the representation of nature seemed to reflect a consensus of group's views. Thus the effects of participation appeared political and the use of knowledge seem to be skewed. Firstly, defining biodiversity as one ecosystem service in the class "conservative services" in the Peatland Strategy was not compatible with widely accepted definitions of ecosystem services (Millenium Ecosystem Assesment, 2003; European Environment Agency, 2016). Secondly, referring to peat as a renewable provisioning service skewed also the use of the concept. However, the main idea of ecosystem services that nature produces various societal benefit from ecosystem processes, was emphasised. Despite of this emphasis, the use of the ecosystem services approach enabled 'business as usual' to continue. Thirdly, advocacy groups proposed and succeeded to include other than ecological experts in the definition of a natural state of peatlands. Guiding use to peatlands that are not in the natural state was a basis for many of the policy means. Participation showed also other peculiar aspects because landowners were not explicitly included in the preparation of political documents nor did their voluntary participation opportunities improve, although they were used as a rationale for voluntary approach.

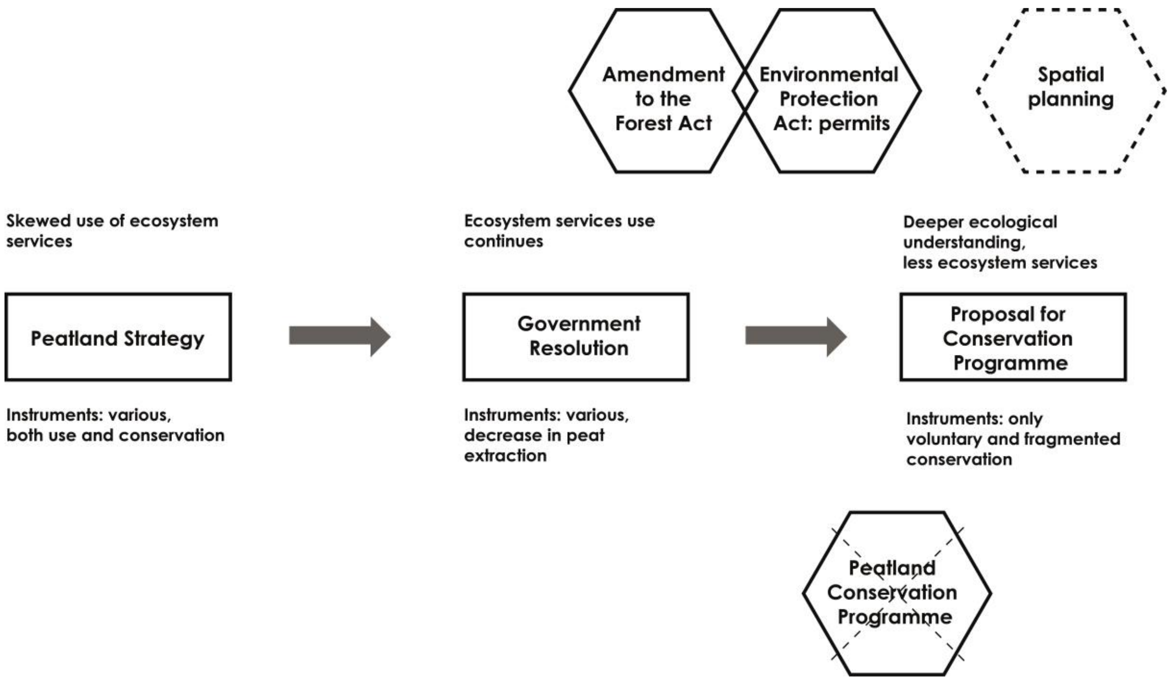

Figure 5 The development of Finnish peatland policy and conservation policy instruments which were implemented (without a cross) or disappeared (marked with a cross) 2011-2015. The main changes of representation of nature and instruments in policy documents are summarized. Spatial planning changed towards more voluntary during the process. During the process political participation caused unalignment between knowledge concerning peatland biodiversity conservation needs and selected policy instruments. Figure from Chapter IV.

Policy priorities evolved during the peatland policy processes along with a change in political power, causing tensions and unalignment between knowledge and policy instruments. From the repertoire of proposed new policy instruments, only a couple were implemented during our study period (Figure 5). Instruments capable of preserving ecologically functioning nature (as part of combination other existing instruments) disappeared from the peatland conservation policy instrument portfolio during 2009–2015. These were Peatland Conservation Programme and binding spatial planning which prioritizes biodiversity. The new peatland conservation was based on the Environmental

Protection Act, which is originally an emissions control act. Permits for peat extraction are only granted when the natural state of a peatland is significantly altered because of drainage. Forest use regulation become more positive towards biodiversity conservation. The State budget for biodiversity conservation decreased, and proposed voluntariness-based conservation (voluntary conservation and restoration) was therefore not ensured. Some instruments and guidelines for preserving carbon storage were recommended, but these were either quite abstract or the same as those used for biodiversity. The instruments, which were implemented during our study period, did not match with existing knowledge (especially the need for ecological connectivity and large areas). Scientific information on the effectiveness of instruments appeared to not be the reason behind the selection of conservation policy instruments, but rather the reason seemed to be a political play and interests of powerful actors.

Different interpretations of scientifically complex knowledge concerning nature can affect the implementation of nature conservation policy instruments and therefore also nature conservation effectiveness, as demonstrated by two cases. Opening the scientific definitions and communication between scientists and policymakers is needed for not to leave room for powerful actors to use science-based concepts in a politically coloured manner.

5.2 Different knowledge types are relevant for gaining more effective results with voluntary policy instruments (II)

We studied which knowledge types are relevant to gaining more effective results with (voluntary) nature conservation policy instruments and how they are used in the implementation (Chapter II). We found that knowledge originating from various scientific disciplines is relevant for voluntary conservation. The role of other knowledges apart from ecological knowledge may be more important when designing voluntary rather than compulsory instruments, because landowners have freedom to participate and they should feel the work is rewarding.

Relevant disciplinary backgrounds that emerged in the discussions included biology, forest sciences and other natural sciences along with social sciences and the humanities. For example, we found biogeography, economics, policy studies, law, socio-psychology and cultural history to be relevant for the context of forest conservation. Climate change knowledge was not considered very relevant in practice because of its uncertainty, which led to difficulties in applying the knowledge in practical context. Various knowledge types for policy objectives can contest each other, for example, permanent conservation was justified by greater ecological benefits, whereas temporary conservation was thought to be better for social reasons such as leaving future options open. The focus group discussions also showed that prioritizing what to conserve is a valuation question that does not necessarily have scientific consensus. Various actors perceived the conservation targets differently. Deciding and communicating ecological priorities were in general thought to be the job of ecologists. Simultaneously however, it was acknowledged that political priorities are decided elsewhere, i.e. in policy circles, and that social and ecological benefits can sometimes conflict with each other.

We found three knowledge-related phenomena that affect the effectiveness of voluntary Forest conservation implementation in our case: interaction and qualities of knowledge, awareness of voluntary conservation options and applying locally bound knowledge (Figure 6). Forest advisers', forest owners' or other actors' awareness of a voluntary instrument is necessary for its implementation. Forest advisers in particular have a key role in raising awareness, because they have trusted relationships with forest owners. Accuracy of species data affects the trust felt towards nature conservation officials and binding instruments (e.g. data on flying squirrels should be up to date and reliably collected). Positive relationships between actors were said to increase the use of available knowledge. We also found that knowledge in practical use is often applied and/or combined with scientific and experience-based and local knowledge. In practical use knowledge was also often transdisciplinary: knowledge on nature was combined with knowledge on social and societal aspects e.g. with the history of a place. The results showed that knowledge is locally bound, i.e. scientific knowledge and other knowledges are interpreted and applied in the context of local knowledge and the context place. For example, a forest adviser or environmental authority decides whether a specific site matches with conservation biology –based ecological criteria, which are decided on when planning a policy instrument.

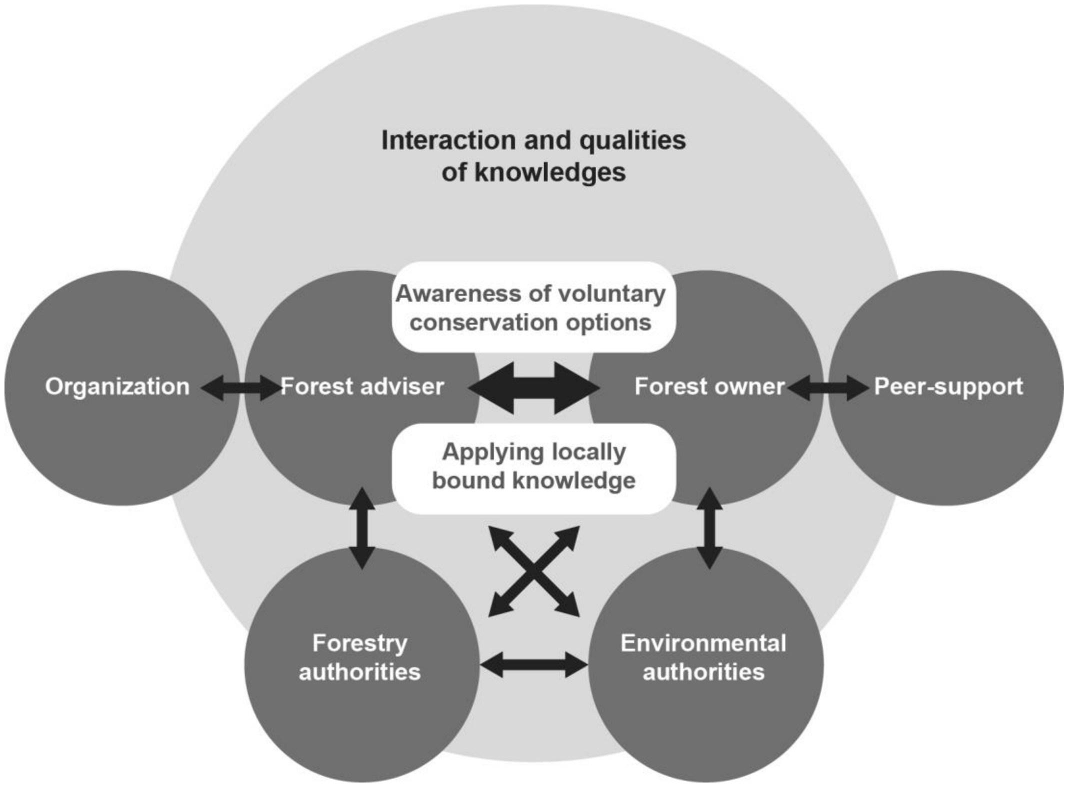

Figure 6 We found that interaction and qualities of knowledges, awareness of voluntary conservation options and applying locally bound knowledge are important knowledge-related phenomena affecting the effectiveness of voluntary nature conservation. The figure illustrates the importance of actor collaboration for using and co-producing knowledge. Figure from Chapter II (Salomaa et al., 2016).

Local-level actors, especially forest advisers and forest owners, were found to be the key persons in interpreting knowledge in the local context of voluntary contracting (Figure 6). Actors interpret various knowledge types and concurrently co-produce new knowledge. Forest adviser often act as a mediator between scientific and local knowledge and between administrative knowledge and the forest owner. Thus advisers' knowledge on conservation aims, means and practices can enhance or prevent conservation implementation. These are linked to personal values and organizational culture. Therefore actors perceptions can make a difference regarding achieving the policy targets. Collaboration that is linked to benefitting from knowledge can improve effectiveness of nature conservation. Local-level smooth social relationships between various actors enable benefitting from the existing knowledge and gaining conservation results.

5.3 How integrative knowledge can be produced for targeting voluntary nature conservation (III)

We studied how integrative knowledge can be produced for targeting (voluntary) nature conservation policy instruments (Chapter III). We integrated results from a landowner perceptions survey with an ecological prioritization of an area. We found that the size and quality of a site and the surrounding landscape affected how strongly an owner's perceptions influenced the prioritization results. We found that prioritization integrating ecological and social information produced an outcome that considerably reduced the loss in conservation value, which is caused by potential conservation tensions. However, we also found that collecting enough survey responses to gain meaningful spatial cover was very resource-intensive.

Integrating ecological prioritization with other knowledge types is important for voluntary conservation implementation. For example, ecological prioritization results could be used (and are already used) when contacting landowners. Another alternative could be to produce different prioritization analyses for regional discussion workshops. Focus group participants recommended combining prioritization analyses with field visits to co-produce understanding of ecologically important areas and to allow negotiation and knowledge exchange between actors. Developing ownership in the prioritization process supports legitimacy and future conservation collaboration.

Forest Biodiversity Programme METSO is an example of integrating social and environmental knowledge into the design of the combination of policy instruments, e.g. it considers the need for increasing good relationships between various actors, information sharing, and voluntary participation is combined with ecological criteria for selecting sites. Our results show that while having functioning ecological criteria, it is also perceived to have succeeded in increasing acceptance and securing conservation agreements. Research is also conducted in connection with the Programme, which can improve practices and was positively acknowledged by various actors during the focus group discussions.

We found that integrating ecological and social knowledges is sometimes challenging because of different data requirements (e.g. spatial cover is needed for spatial analysis vs. low response rates are normal in surveys). Integrative knowledge co-production was studied in actor's perspective in previous section (Chapter II) and it showed that challenges may arise because of different knowledge levels or values. Of course there are several other possible challenges for integrating knowledge in research contexts, practical knowledge co-production of different actors and other attempts produce integrative knowledge for increasing conservation effectiveness. However, the integration of various knowledge types can be fruitful and advance conservation. The beneficial combination of various data and knowledge types is context-specific.

5.4 Interaction between knowledge and policy process - Challenges and opportunities for increasing nature conservation effectiveness

In this section we summarize the insights from the different Chapters concerning opportunities for increasing the effectiveness of nature conservation. Our results from cases studied through and with actors suggest that the use of scientific knowledge in conservation implementation can be enhanced by understanding interaction between knowledge and policy process, but we also found some challenges. Based on our results, various phenomena challenge the effectiveness of nature conservation and different opportunities emerge for increasing effectiveness in various phases of the policy process (Figure 7).

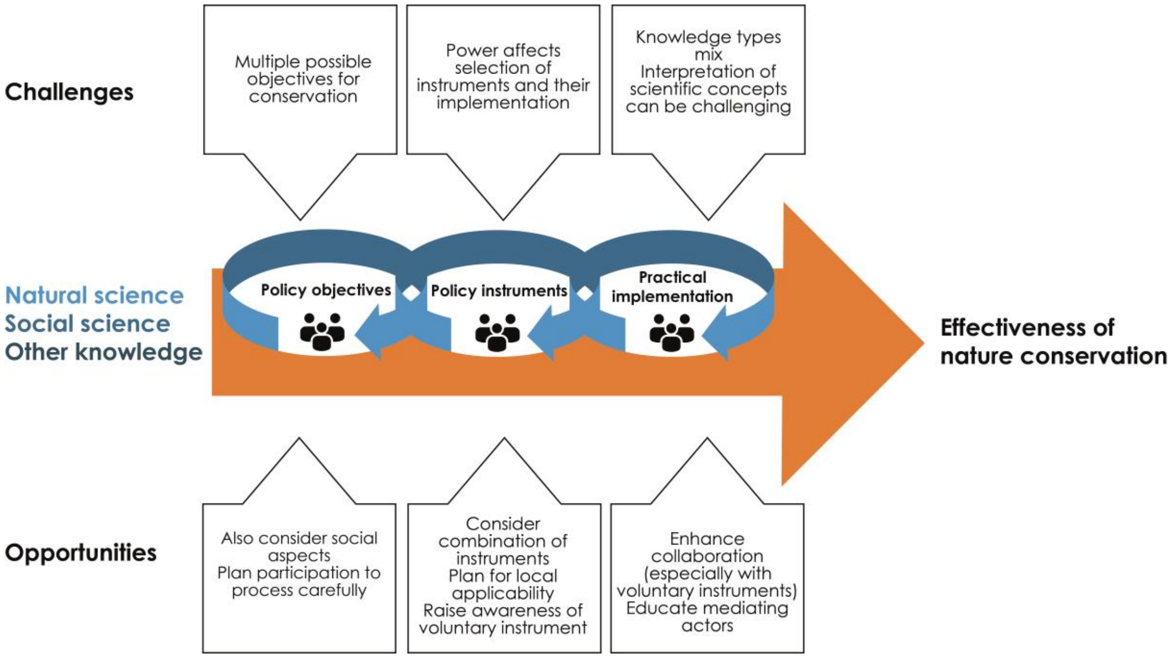

Figure 7 Interaction between knowledge and policy process faces challenges and offers opportunities for increasing nature conservation effectiveness. Figure summarizes insights from different cases (Chapters I, II, III and IV).

In the phase of deciding policy objectives, there exists multitude of possible objectives. Power-relationships and participating actors affect the selection of policy objectives. Even when the selected policy objective is nature conservation, there are different alternatives of what to emphasize and a various actors are involved. Policymakers should thus recognize the importance of different knowledge types, even when only focusing on conservation effectiveness. Considering social aspects in addition to ecological aspects is important for the definition of nature conservation policy, policy instrument selection and implementation when developing effective and accepted policies such as the Forest Biodiversity Programme.

Power affects the selection of instruments and their implementation. In a case of conflicting policy process, as in peatland conservation, policies benefitting from ecological knowledge can be overrun by powerful interest groups. This highlights the importance of acknowledging power differences in the participation process. Participation to different phases of policy process should be carefully planned to avoid situation where powerful parties advance their own interests in a harmful way, even this may be difficult to put into practice. Ambiguous concepts leaves room for politically coloured use. Results of a policy approach that includes complicated knowledge, as with green infrastructure, can be compromised, and instruments and implementation should therefore be carefully planned. A combination of policy instruments and their strengths and weaknesses should be considered when planning holistic biodiversity policies. Our results show that policies should be designed in a way that allows for practical and local application of knowledge, but simultaneously should be ensured that scientific concepts and ideas behind them are not blurred or skewed. For example, guidelines for conservation area selection should be clear in the practical context. Efforts should be made to raise awareness of a voluntary instrument and participation should be made attractive to land owners and other actors.

The way in which scientific knowledge is used during local-level policy instrument implementation is affected by the valuation of different knowledges. In implementation phase various types of knowledge mix, as actors hold different types of knowledge. Interpretation of scientific concepts can be challenging for practical actors. Forest-advisers' lack of knowledge concerning nature or conservation requirements and processes can prevent them from advising on how best to implement voluntary conservation instruments. Effective conservation implementation involves efforts to ensure interaction and collaboration between local-level actors, and between them and scientists. Enhancing collaboration in projects targeting to the conservation of nature was perceived as fruitful in many ways. With a voluntary forest conservation instrument, the collaboration of actors enabled integrating local knowledge with scientific knowledge, which is an integral part of increasing conservation effectiveness. Science-policy (and practice) interaction key actors should be able to account for the interaction of different knowledge types. Emphasis should be placed not only on summarizing ecological research to practical actors, but also on incorporating knowledge from other disciplines, and from the local level to the policy implementation process. Awareness of conservation options and the scientific reasoning behind them can be increased by educating forest advisers and supporting positive relationships (creating chances for learning and building trust) between forest owners and other actors. Forest owners' knowledge concerning the reason for conservation was expected to increase participation in voluntary conservation. However, knowledge needs and forest owners were described to vary: some forest owners know more than the forest advisers, some are only interested in the monetary aspect while some focus on recreational issues. Actors also emphasized that it is generally beneficial to refrain from using scientific concepts when encountering landowners.

6 Discussion

6.1 How does understanding interactions between knowledge and policy process contribute to increasing the effectiveness of nature conservation?

I have studied empirical cases of interaction between knowledge and policy process focusing on different knowledge types and policy instruments to understand how to improve existing practices. I have studied actors' perspectives and their roles on opportunities to increase the effectiveness of nature conservation. The conceptual and theoretical contributions of this thesis are in increasing the understanding of the interaction between knowledge and policy process contributing to conservation effectiveness. This thesis shows that implementing policies that are based on ambiguous concepts (i.e. ecological connectivity and ecosystem services) can possibly lead to a non-optimal direction compared to a policy objective. For example, using the EU green infrastructure policy approach, which was developed for biodiversity conservation, can be used to advance other political aims (Chapter I). Ecosystem services and ecological connectivity can be interpreted in different ways in practical situations, and the use of a science-based concept can be coloured for political purposes (Chapters I and IV). Participation does not necessarily produce legitimate or effective conservation when actors with other strong interests are involved (Chapter IV). This thesis demonstrates the relevance of different knowledge types to the effectiveness of voluntary conservation (Chapters II and III). Mixing various knowledge types is inevitable in practical decisions (Chapter II), but different knowledge types can also be integrated with the purpose of increasing conservation effectiveness (Chapter III). The contribution of this thesis is especially relevant in the context of voluntary contracting and collaboration between various actors of science-policy and science-practice interfaces. This thesis shows the central role of actors and their perceptions as well as the knowledge intensity and importance of local contexts to the nature conservation. It touches timely policies (especially 2009–2015) and shows how different phases of policy process faces challenges and offers opportunities for increasing nature conservation effectiveness. As the study covers the main habitat types of the Finnish landscape and the most important policy instruments, it also offers a view of understanding national-scale governance of nature. The results of this thesis can help to plan and implement more effective conservation policies.

Our study contexts (peatland, forests and green infrastructure) are intertwined, but certain aspects contrast each other. Green infrastructure is a relatively new policy approach and its implementation in the Finnish context remains still open in 2017. Green infrastructure offered a case to consider the expert perspectives on developing a new policy approach. The cases of peatland policy and voluntary forest conservation offered differing aspects to policy, despite many of the instruments and actors being the same. With voluntary conservation, tensions between actors are smaller, and various knowledges are easier to treat as objective and to be integrated. In contrast, with highly politicized peatland policy, the use of knowledge was easier to consider with a lens of power-relationships and politics. What makes these cases even more interesting is that conserving peatlands as conservation areas is actually relatively widely accepted by the general public and landowners. Voluntary actions offer more flexibility, opportunities for experimentation and possibilities for additional aims than those regulated by binding instruments. Voluntary actions should be used in this role rather than displacing binding regulations with voluntary ones. This also highlights the importance of developing instruments, which has succeeded in increasing acceptance and advancing conservation, such as the Forest Biodiversity Programme. However this does not imply that voluntary-based conservation works similarly in all habitats e.g. in peatlands, where one catchment basin (one mire) may have numerous landowners. The content of concepts, such as the ecological connectivity concept, must therefore be discussed, and their importance clarified and specified in the context of the relevant habitats. Focusing solely on one case, or using only one theoretical conceptualization of the interaction between science and policy would make the conservation policy appear simpler than what it is in reality. The multi-perspective, multi-theoretical approach used in this thesis offered more diverse views on science-policy (and practice) interactions than any single theoretical background model could provide (Pregernig, 2014).

Implementing the green infrastructure approach or something alike is necessary to avoid deterioration of important ecosystems in Finland because actions destroying or deteriorating nature are largely seen as separate from each other (sectoral governance) (see Maes et al., 2015), and consequently some of the impacts are not covered by legislation (Similä et al., 2017). Our results showed that the contribution of a dedicated EU policy for green infrastructure on biodiversity conservation is dependent on how green infrastructure will be implemented in practice, and that the existing conceptual ambiguity may challenge the potential opportunity to increase nature conservation effectiveness that green infrastructure has to offer. This is partly because of the key role that ecosystem services play in defining and implementing green infrastructure and the challenges of realizing the full potential of existing policy instruments. Results show that during implementation, the focus should not lie solely on ecosystem services (see also Gomez-Baggethun and Ruiz-Perez, 2011; Redford and Adams, 2009; Schröter et al., 2014). We found that green infrastructure was not perceived to facilitate a strong change in environmental policy. This indirect change could be modifying the consideration of environmental and/or land-use planning in favour of more holistic approaches (Lennon and Scott, 2014), e.g. addressing the interaction between various scales, or mainstreaming ecosystem services to other policy sectors (Kettunen et al., 2014). On the other hand, emphasis on ecosystem services could change policy to a more utilitarian direction, which stresses the monetary benefits gained from nature (Garmendia et al., 2016; Lennon, 2015a; Thomas and Littlewood, 2010). Ecosystem services concept have both value and limitations when used in conservation (Schröter et al., 2014). As sometimes it might be possibly to only see afterwards how the concepts has worked in a particular case, it should not be seen as the main focus in conservation policies. However, understanding the meaning of ecosystem services and natural capital - simply nature’s fundamental role for society - would be at the heart of the change needed in economic theory and practice to achieve a sustainable future (Costanza et al., 2017). As the use of ecosystem services concept in IPBES shows, at least in the global scale biodiversity science-policy interaction there is a need for also a wider concept than ecosystem services (not only services, but nature's contributions to people).

During the period that we followed the conflicting peatland case, political power changed and in the end of the period the implemented policy instruments did not match with existing ecological knowledge. Instruments that could have been capable of preserving ecologically functioning nature (new conservation programme or binding spatial planning which prioritizes nature) as part of combination other existing instruments disappeared from the peatland conservation policy instrument portfolio during 2009–2015. The areas that are preserved because peat extraction doesn't get environmental permit are random and not systemically selected. Overall, the conservation policy instruments changed to emphasize voluntariness but without an adequate budget to ensure enough conservation. A holistic approach that accounts for ecological functionality would be better for ensuring ecological functionality and could be implemented on the national scale e.g. by using habitat conservation programme or land-use instruments, and in particular using the green infrastructure approach. However, our results with green infrastructure case showed that implementation of the green infrastructure with land-use planning instruments would require strengthening the role of ecology in land-use planning systems (Lennon and Scott, 2014).

The possible indirect change caused by green infrastructure can also go in another directions, for example to focus on cities (Maes et al., 2015). Urban green infrastructure can offer nature-based solutions, which has become one of the buzz words in EU environmental policies (European Commission, 2015). Cities have growing importance in multi-scalar and networked environmental decision-making (Bulkeley, 2005) as the their number of habitants and economic importance increases. Anyhow, in order to conserve biodiversity, the amount, quality and connectivity of core areas should also be considered at landscape and wider scales. The importance of biodiversity conservation should receive a more explicitly defined role in the EU biodiversity policy and its implementation A need to improve the implementation of existing biodiversity policy instruments is as an integral part of developing a green infrastructure, or when developing environmental policy more generally.

Implementing instruments based on complex scientific concepts with multiple interpretations, such as green infrastructure, ecosystem services or ecological connectivity, can be challenging. However, ambiguity may have helped the concepts to create political momentum (Lennon, 2015a) and to lead to discussions concerning the different interpretations of the concept (Lennon, 2015b; Wright, 2011). My research has contextualized the question of conceptual ambiguity and its potential consequences of green infrastructure and ecosystem services in Finnish policy context. This thesis has an empirical approach and it touches only a surface of theoretical discussions. In any case, the theoretical-conceptual questions related to ambiguity and uncertainty are also central when having problem oriented approach to environmental problems. Also many other central concepts have ambiguous meanings, for example the concept of sustainable development.

In common decision-making we have to deal with the various realities of different actors. Science should be clear, relevant and fair for it to be effective (Cash et al., 2003). However, complex environmental problems and ecological holistic dynamics may be difficult or even impossible to summarize in a clear manner. There exist a large body of literature on making more usable science, for example, reframing science with a political context, presenting a persuasive narrative and engaging in boundary work have been recommended (Rose, 2015; Rose et al., 2016). Researchers can produce usable knowledge when understanding coproduction relationship of knowledge and decision-making and putting understanding into action by building capacities for collaboration, social learning, knowledge governance and researcher training (Clark et al., 2016). Coproduction relationship of knowledge and decision-making means that knowledge, policy and practice are continuously reshaping another (Clark et al., 2016). Our results show that in practical situations knowledge concerning biodiversity can be a mixture of local and scientific knowledge. This is not surprising as knowledge is inherently personal (Raymond et al., 2010). This highlights the importance of interaction between practitioners and scientists, which enables the coproduction of various actor groups' knowledge (Edelenbos et al., 2011). Our results explained that interaction can help in planning guidelines that are clear, scientifically robust and applicable in practice. In our case with a voluntary approach, the actors didn't have especially strong tensions which possibly advanced collaboration and can enable integrating knowledge types. Possibly the risks of participation to environmental projects and knowledge coproduction (Luyet et al., 2012) can be more easily overcome in this kind of cases where participants don't have strong interest differences. Van Kerkhoff and Lebel (2015) have suggested a concept of coproductive capacities to help to identify which interventions may enable evidence-informed but locally sensitive approaches to environmental governance. They suggest that history, experience, and perceptions; quality of relationships; disconnection across scales; power, interests, and legitimacy; and alternative pathways for governance are important (van Kerkhoff and Lebel, 2015).

The role of other knowledge types along with ecological knowledge, social knowledge in particular, is relevant for achieving effective nature conservation and may be more important with voluntary than compulsory instruments. This is because individuals decide on participating to voluntary actions. The integration of ecological prioritization with other types of knowledge appears to offer advantage over solely using ecological knowledge in voluntary conservation implementation. Nature conservation effectiveness therefore requires considering the ecologically optimal solution and getting landowners to participate. Considering social issues is also important for effectiveness of command and control type instruments in the long run, because an unsatisfied landowners can find ways to resist unwanted conservation. We found that different ways of integrating ecological prioritization and social knowledge include using ecological prioritization results when contacting landowners, producing prioritizations for regional discussion workshops or combining prioritization analyses with field visits to co-produce knowledge. Other alternatives exists, for example, land owners could mark their interest to participate to conservation in forest database as suggested e.g. by Harlio (2017). Integrating ecological and social knowledge for creating opportunities for increasing nature conservation effectiveness requires understanding contextual factors.

Participatory decision-making approaches offer effective tools (van den Hove, 2000), but actors should not been seen as apolitical. In the conflicting peatland case, the participation to policy preparation of powerful stakeholders, who were pro peat extraction, led to a skewed definitions of ecosystem services and the natural state. Definition of ecosystem services seemed to be changed to suit the political purposes of the participants, and the scientific knowledge of a natural state of peatlands was blurred with a participatory definition process. The valuation of different policy objectives is a political decision, but the definition of the natural state should not be. Democratizing knowledge (production) should not be used for turning opinions into facts (Lockie, 2017). Using a participatory approach during policy development is not automatically fair, attention should be paid to power positions and lobbying resources. Strengthening the scientific basis of policy actions seemed to be more commonly agreed among actors in voluntary conservation, who did not have strong interest differences, than actors in peatland policy, who on the contrary had conflicting interests. In addition, the resolution to only use voluntary means in peatland conservation policy was defended by landowner freedom, although landowners were actually not heard out. Our results show an indication towards the direction of post-truth politicians, who manufacture their own facts (Lockie, 2017).Who can decide what to be conserved is a sensitive question and potentially sensible to conflicts. However, it is debatable if any knowledge can be value free. Calls for actor participation in making science (as in post-normal science, Funtowicz and Ravetz, 1993) complicate the question even further. However, I claim that at least in cases where scientific knowledge exists, actions that aim to further conservation effectiveness should be evidence-informed but without forgetting other types of knowledge or consideration of stakeholders.

Our results showed that engaging landowners and other actors in the conservation prioritization process could improve the success of conservation plans and therefore offers opportunity to increase nature conservation effectiveness. Smooth social relationships were enabling factors in the implementation of voluntary conservation (see also Cash et al., 2003; Oliver et al., 2014). For example, forest advisers and fellow forest owners can advance the awareness of conservation options and an individual's participation in conservation, which is also noted by previous research (e.g. Korhonen et al., 2013). Attitudes toward conservation evolve through social interaction (e.g. Bergseng and Vatn, 2009), decreasing tensions attached to top-down expert-driven conservation (Winkel et al., 2015). Collaboration between various actor groups also helps to communicate “different system logics” of scientists and other actors. Scientists might benefit from better understanding the policy process and the role of other knowledges apart from science in their field, whereas practitioners might benefit from understanding science production and the timescales and processes of validating science and its accumulation. Enhancing collaboration between the various actors of the science-policy (and practice) interfaces could therefore provide ways to increase the understanding of science. Interaction between science, other knowledge types and policy processes can also be supported with science-policy platforms or other boundary organizations. Nature conservation effectiveness should be defined based on ecological knowledge, while openly discussing the various valuations of nature. However, ecologist should also be prepared to discuss where nature conservation is compared to other policy objectives. However, collaboration and participation should be approached cautiously in cases with strong political interests. The dialogue between science and various phases of the policy process should be strengthened to avoid decrease in the weight of scientific understanding or even strengthening or entering to the post-truth era. Whether neglecting scientific facts is an indication of a new era, or just a normal way of the policy process, remains unanswered by my results. In any case a vital need exists for more holistic nature conservation, also for the sake of the people. Collaboration offers opportunities for increasing the effectiveness of nature conservation. Collaboration in knowledge coproduction and use and in policy actions is needed to solve global environmental problems.

Increasing understanding concerning the interaction of knowledge and implementation to conservation effectiveness is relevant for environment policy, but especially for conservation biology which is still largely dominated by a linear model of knowledge transfer (however, see Adams and Sandbrook, 2013; Toomey et al., 2016). The complexity of science-policy interactions is not new in environmental social sciences (van Kerkhoff and Lebel, 2006), but studying nature conservation cases in this thesis makes complex interactions more understandable to those who have background in natural sciences. Conservation science has largely seen conservation as a matter of understanding nature better, but it has become increasingly interdisciplinary and social sciences have become a vital element for achieving effective conservation (Bennett et al., 2017). Traditionally, the research on the effectiveness of nature conservation has not taken seriously the effects of roles and perspectives of plural actors, knowledge intensity and boundedness to local contexts of conservation and interaction of these with the policy processes. Conservation community should recognize that conservation is a reflective socio-political question similarly to climate change adaptation (Wyborn et al., 2016). Deepening the understanding of various ecological paradigms and environmental concepts in this thesis contributes to the theoretical conceptualizations and models of knowledge-action interaction. Opening the role of different knowledges and the political use of knowledge also contributes to environmental sciences. Understanding, making visible and benefiting the diversity in the different way that people see nature and nature’s contributions to people is argued to advance transformative practices towards sustainable future (Pascual et al., 2017). It also requires addressing power relationships across actors (Pascual et al., 2017).

6.2 Limitations of this study and future research needs

As I have chosen to study various aspects of knowledge and policy process interaction and in different cases, the results are not as comprehensive as studying only one case from various angles. However, I have made this decision on purpose because I consider holisticity important for solving environmental problems, even if the level of details is compromised. This chosen approach provides insights to the interaction between different knowledges and the policy process. However, this thesis does not cover the whole image of all possible cases. The knowledge use in the peatland case differed from other cases because actors had strong interest differences. However, it is possible that other reasons affect to interaction of knowledge and policy process, for example, uncertainties regarding nature can make them difficult to be governed. For increasing nature conservation effectiveness with social sciences, useful lessons can be learned, for example, from research fields of interdisciplinary research, knowledge coproduction, science-policy interface or science communication (Bennett et al., 2017). Actual nature conservation effectiveness should be measured using the change in nature. I have chosen to approach effectiveness by studying cases through and with actors, because people determine how research is conducted, and how it is used in decision-making and in practical situations.

The survey results in Chapter I had certain limitations. Counting performed with the survey responses was a heuristic approach, sufficient for the goal of discussing actor's perspectives on potential implementation of green infrastructure. Professionals who had a background in forestry, biology and interdisciplinary sciences were over-represented, while local-level professionals were under-represented. Because of the small sample size, comparing the perceptions of different respondent groups was not possible even though they might differ. Over-representation reflected the disciplines that have made major contributions to landscape-level conservation in Finland, while under-representation showed that local-level green infrastructure implementation was not topical at the time the survey was sent. The opinions of local-level practitioner will also become relevant in the future. No responses were received from the Ministries despite efforts to include them, probable because of time constraints. Involving more participants from Ministries also in focus group discussions in Chapter II and III would have been ideal.

We did not separate the opinions of different actor groups either in Chapters II and III. Many of the participants probably had positive attitudes towards the Programme, although we also involved landowners that were known to be critical. The conflicting peatland conservation policy case showed that various actor groups can have different aims and power to influence the implementation of environmental policy. Comparing the perceptions of various respondent groups would be an important addition to research designs in future. Chapter IV is a case study showcasing Finnish power balances and the policy system, thus results as such are subjective and not transferable. However, the case illustrates some of the possible dynamics in policy development and an interesting aspect on interaction between knowledge and the policy process.

Getting all private landowners in our study area to respond to the questionnaire in Chapter III would have been too resource-intensive. The low response rate limited the usefulness of the prioritization results, but they can still be used to advance approaches that include both social factors and prioritization. This finding illustrates the difficulties of using surveys in practical voluntary conservation prioritization. The results of prioritization depend on the assumptions made in the analysis. We used habitat classifications that enabled any valuable site to be fairly easily replaced by another. Prioritization results are not transferable because of their context-specificity. The assumptions and results could be interpreted in collaboration with relevant actors with the aim of engaging these actors in practical conservation. This approach can be generalized to other contexts as well.

A need exists to widen and deepen policy process frameworks and science-policy interface theories from science-policy interaction to the interaction of science and other knowledges and to various phases of the policy process. Another option would be to study deeper the hierarchically different knowledges that are relevant during various phases. Deepening the analytical division on the heterogeneity of knowledge would be recommended in future studies. Widening frameworks could be done by conducting more case studies, and later synthesizing the results of the various cases. Alternatively the impacts of the outputs of science-policy interfaces could be evaluated.

This thesis is interdisciplinary, but furthering research to numerous other interdisciplinary directions could have practical relevance to the sustainability transition that our societies need in the near future. It would be useful to relate increasing discussion of voluntary actions and win-win solutions regarding nature to the discussion of environmental limits and continue also to the direction of intersection of knowledge and adaptive governance (Wyborn et al., 2016) to identify and implement actions which enable evidence-informed but locally sensitive approaches (van Kerkhoff and Lebel, 2015). Guidelines to increasing nature conservation effectiveness would benefit greatly from relating them to social transition research.

In this thesis I have studied actors' perceptions and their roles in nature conservation effectiveness. It is essential that in future research and practice the involvement of actors is combined with the evidence-informed approach (Adams and Sandbrook, 2013) because it increases the understanding of possible solutions to complex problems, along with actor' ownership and use of research findings.

6.3 Conclusion

Understandings of interaction between knowledge, policy process and nature should be inclusive or at least pluralistic to improve nature conservation and human well-being. I argue that the use of scientific evidence must be combined with the usage of other knowledge types and involvement of various actors. In addition, potential interest differences of actors should be considered when planning participation. In this way a combination of policy instruments can be developed, which simultaneously increases evidence uptake, acceptance and effectiveness leading to a more sustainable future.

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